QC
Pat 36
3295
5273

Volume 7 DECEMBER 6, 1932 Number 6

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

Library of Congress
DEC 12 1932
Smithsonian Deposit

PROGRAM

OF THE

PASADENA MEETING

AT THE

CALIFORNIA INSTITUTE OF TECHNOLOGY

PASADENA, CALIFORNIA

DECEMBER 16–17, 1932

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SEVEN ISSUES EACH YEAR

QC
.A56

The American Physical Society

OFFICERS OF THE SOCIETY FOR 1932

President	W. F. G. SWANN	Bartol Research Foundation
Vice-President	PAUL D. FOOTE	Gulf Research Laboratory
Secretary	W. L. SEVERINGHAUS	Columbia University
Treasurer	G. B. PEGRAM	Columbia University
Editor	JOHN T. TATE	University of Minnesota
Local Secretary for the Pacific Coast	L. B. LOEB	University of California

COUNCIL

The council of the Society consists of the president, vice-president, secretary, treasurer and managing editor as given above, and all living past presidents and eight elected members as follows:

Past Presidents: Carl Barus, E. L. Nichols, Henry Crew, W. F. Magie, Ernest Merritt, R. A. Millikan, J. S. Ames, Theodore Lyman, C. E. Mendenhall, D. C. Miller, K. T. Compton, and H. G. Gale.

Elected Members: H. E. Ives, A. L. Loomis, L. W. McKeehan, D. L. Webster, W. D. Coolidge, F. W. Loomis, F. L. Mohler, and J. H. VanVleck.

BULLETIN

of the

AMERICAN PHYSICAL SOCIETY

Published seven times per year

Subscription price: $5.00 per year

Single copies: $1.00 each

The Bulletin of the American Physical Society is published seven times a year during the months of February, April, June (2 issues), November (2 issues), and December at Prince and Lemon Streets, Lancaster, Pa.

Address correspondence to Prince and Lemon Streets, Lancaster, Pa., or to Secretary W. L. Severinghaus, Columbia University, New York, N. Y.

Application for entry as second-class matter at Lancaster, Pa., post-office, pending.

DECEMBER 6, 1932 Vol. 7, No. 6

BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

PASADENA MEETING, DECEMBER 16–17, 1932

The 181st regular meeting of the American Physical Society will be held at the California Institute of Technology, Pasadena, California, in the lecture hall, room 201, of the Norman Bridge Laboratory of Physics, on Friday, December 16, and Saturday, December 17, 1932. The morning session of the Physical Society will begin at 9:30 o'clock on Friday, and the afternoon session at 2:00 o'clock on the same day. The session on Saturday morning will begin at 9:30 o'clock and will be resumed at 2:00 o'clock if the number of papers warrants. Saturday afternoon, unless spent in session, will be open for tours of inspection of the Norman Bridge Physical Laboratory and the W. K. Kellogg Radiation Laboratory of the California Institute of Technology.

Titles and abstracts of the papers to be presented at this session will be given in the following pages. These abstracts have not been corrected by the authors. After correction they will be published in an early number of the Physical Review. Authors should send all corrections to the Editoral Secretary, American Institute of Physics, Incorporated, 11 East 38th Street, New York, N. Y.

Arrangements will be made for a dinner on Friday evening, December 16 and for luncheon meetings at the Atheneum at noon on Friday, December 16 and Saturday, December 17.

Hotel Accommodations. (Note: Distances from California Institute of Technology given in parenthesis.)

Constance—940 E. Colorado St. All rooms with bath. Single rooms about \$2.50 to \$5.00 per day; (½ mi.)

Crown—677 E. Colorado St. Single, with bath, about \$2.00 to \$3.00; (¾ mi.)

El Rey—87 E. Green St. Single, about \$1.00 to \$1.50; (shower) \$1.50; with bath, about \$2.00 to \$2.50; (1½ mi.).

Grant—127 N. El Molino Ave. Single, with bath, about \$2.00; (1¼ mi.).

Green—Corner Raymond Ave. and Green St. Single, about \$2.00 to \$2.50; with bath, \$2.50 to \$4.00; (1½ mi.).

Huntington—South Oak Knoll Ave. Single, with bath, about \$4.00 per day; (½ mi.).

Park View—Corner Raymond and Green St. Single, \$1.50 to \$2.00; with bath about \$2.00 to \$2.50; (1½ mi.).

Clark's Auto Camp—3019 E. Colorado St. All modern conveniences may be obtained for about \$1.50 per day.

(Note: All of the above hotels have double rooms as well as single.)

Other meetings for the current season are as follows:

182. Atlantic City. December 28–30, 1932. Annual Meeting.
183. New York City. February 23–25, 1933. Joint meeting with the Optical Society of America.
184. Washington. April 27–29, 1933.
185. June, 1933. Pacific Coast. Time and place to be announced later.
186. Chicago. Week of June 19, 1933.

LEONARD B. LOEB, *Local Secretary for the Pacific Coast,*
University of California,
Berkeley, California.

December 6, 1932.

DEC 10 1932

PROGRAM

FRIDAY MORNING, DECEMBER 16, 9:30 O'CLOCK

Lecture Hall, room 201

1. New method of measuring electric and magnetic properties of metals in the region of ultra-short electromagnetic waves. G. POTAPENKO AND R. SANGER, *California Institute of Technology.*—In a Lecher system, which consists of two parallel wires and two connecting bridges, the distance between the bridges in the case of resonance does not correspond exactly to the half wave-length. It is always shorter than the half wave-length, the difference being called Brückenverkürzung by Drude. Its value depends upon the reflecting power of the bridges used and this is affected by the self induction of the bridges (Drude's theory) and by the resistance of the bridges (exact theory). A plate, the size of which is at least of the order of half of the wave-length, is used as one bridge (the plate-bridge, perfectly reflecting). The other bridge consists of wires of different materials and of different diameters (the wire-bridge, poor reflection). Resonance studies make it possible to measure the bridge contraction and the damping of the Lecher system for all kinds of wire used. A theory of the propagation of the waves along the wires of a Lecher system taking into account the perceptible resistance of the bridge is developed. This makes it possible to calculate the values of the resistance of the wire-bridge from the measurement of the bridge contraction and of the damping of the Lecher system. Hence, taking into account the skin-effect and comparing the results for non-magnetic bridges with those for magnetic bridges, or the results for bridges of different diameters, the electric conductivity and the magnetic susceptibility of the metals of the wire-bridges can be evaluated. The proposed method is checked by preliminary measurements on copper and iron bridges by the use of undamped waves in the region of wave-lengths from 10 to 100 cm.

2. A sensitive stellar photometer. SINCLAIR SMITH, *Mount Wilson Observatory.*—A very sensitive stellar photometer consisting of a photoelectric cell attached to a Hoffmann electrometer has been installed at the Coudé focus of the sixty-inch telescope. The photo-cell is mounted on a short length of brass tubing which in turn is mounted on the electrometer in such a way that the space surrounding the anode extension of the cell can be evacuated. When this space and the electrometer case are evacuated, both surface leakage over the quartz insulation and the effect of stray ions in the air are eliminated. The excellent quartz cells made by Dr. Kunz of the University of Illinois are used in this photometer as the extremely small dark current of these cells allows one to use the full sensitivity of the Hoffmann electrometer. Photo currents down to 30 electrons per second have been measured with this instrument, but routine work has been confined to stars brighter than the 14th magnitude which release approximately 500 photoelectrons per second. On stars fainter than the 14th magnitude, natural fluctuations in the primary response (i.e., the number of photoelectrons emitted per second) which of course set a limit to the sensitivity of all photoelectric devices, become prominent, so that it becomes necessary to use observing times which are unduly long for routine work.

3. Determination of e/m for an electron by a new deflection method. FRANK G. DUNNINGTON, *University of California.*—To fill the need of a new deflection determination and to provide a more accurate value, a new deflection measurement of e/m is being made. The method used was conceived by Professor Ernest O. Lawrence. The essential points of the method are: Acceleration of electrons to a continuous range of velocities by a radio frequency electrostatic field, choice of a particular velocity by magnetic field resolution, measurement of this velocity through radio frequency fields applied to a pair of accelerating slits and a pair of decelerating slits. A most important advantage of this method is that no acceleration voltage need be measured. This, combined with other properties of the method, practically eliminates errors due to contact potentials. Another advantage is the very high observational precision the method makes possible. The present results, although still preliminary, are of an accuracy comparable with published values. The value obtained from two groups of observations made at different electron velocities and with the calculated probable error is $e/m_0=(1.7592\pm0.0006)\times10^7$ e.m.u. The major part of this probable error is due to allowance for possible errors in the magnetic field measurement. However, to allow for still other possible errors the present results may be stated as $e/m_0=(1.7592\pm0.0015)\times10^7$ e.m.u.

4. The value of e/m. RAYMOND T. BIRGE, *University of California.*—Dunnington's value of $e/m=1.7592\pm0.0015$, from magnetic deflection of free electrons, removes the last apparent discrepancy between the results of various methods. Further recent results, of comparable accuracy, are (1) Perry and Chaffee, 1.761 ± 0.001, from electric acceleration of free electrons, (2) Kirchner (weighted average of two results) 1.7587 ± 0.0009 from the same method, (3) Campbell and Houston, 1.7579 ± 0.0025 from Zeeman effect. The weighted average of these four results is 1.75953 ±0.00059 from internal consistency, and ±0.00044 from external consistency. The four results are thus quite consistent with one another. Assuming them to be of *equal* accuracy, one obtains the unweighted average 1.75920 ± 0.00044. Hence 1.759 ± 0.001 appears to be a conservative estimate of the present best direct determination of e/m. Combining this with all available data on e and h (i.e., the writer's solution *l* of Phys. Rev. **40**, 319 (1932) but with a numerical error corrected), one obtains $h=(6.5420\pm0.0083)\times10^{-27}$ erg.sec, $e=(4.7668\pm0.0038)\times10^{-10}$ *e.s* units. $e/m=(1.7592\pm0.0011)\times10^7$ *e.m* units, $1/\alpha=137.374\pm0.048$, as the present most probable values of these constants.

5. The sun and cosmic rays. ROBERT A. MILLIKAN AND H. VICTOR NEHER, *California Institute of Technology.*—New experiments with instruments of increased sensitiveness have been made both at low and at high altitudes. These reveal no trace of a direct solar influence. If any such influence exists it is shown to be so minute in comparison with the indirect influences which produce changes in the atmospheric blanket as to be negligible in comparison.

6. The elastic scattering of electrons by mercury atoms. EDWARD B. JORDAN AND ROBERT B. BRODE, *University of California.*—The angular distribution of electrons scattered elastically by single mercury atoms was studied for electrons of 10 to 800 volts energy and in angle range of 5° to 172°. The values of the atomic scattering coefficient, P_θ, the number of electrons scattered per atom, per unit electron current density, per unit solid angle at an angle θ to the original beam, were calculated from the observed data. The measurements of previous observers were checked in the region from 5° to 120° and new maxima were observed in the region between 120° and 172°. The value of P_θ was found to rise to a relatively large maximum at or near 180° for most of the velocities studied.

7. Direct fusion method for determining the radium content of rocks. ROBLEY D. EVANS, *National Research Fellow. University of California.*—New principles for removing radon from rocks and for measuring minute quantities of radon are presented. Powdered rock specimens are boiled without flux by direct heating in a vacuum, graphite, resistance furnace. The duration of heating is 2½ minutes, which is to be compared with one hour for the quickest of former methods. The gases from the melt are led through an electrostatic ion-trap to the ionization chamber. A small insulation drying device in the ionization chamber protects the amber from water vapor. The natural observational limit for measurements of small quantities of radon is defined as the point at which the average ionization from the radon just equals the probable statistical variation in the background ionization due to cosmic and local radiation, and an apparatus is described which permits measuring radon down to this limit. A string electrometer measures only the difference in ionization in two identical ionization chambers, both of which contain the same background gases, but only one of which contains the radon to be measured. A systematic study of the percentage of the total radon removed from biotite granite as a function of (a) temperature, (b) duration of heating, (c) fineness of sample grains, showed that temperature is the only important factor, and that 1800°C effects complete radon removal.

8. Portable roentgenmeter. CHARLES C. LAURITSEN, *California Institute of Technology.*—In work with high potential discharge tubes or other powerful sources of short wave radiation it is of the utmost importance to have exact knowledge of the amount of radiation to which the worker is exposed. This can be obtained most accurately by means of an *r*-meter carried by the person at all times. A convenient form of such an instrument is described. It consists of a small ionization chamber, electroscope and microscope mounted within an aluminum housing of the general size and shape of a fountain pen. The electroscope consists of a gold-coated quartz fibre of diameter 3μ and length 3 mm. one end of which is secured to a fine supporting wire. The instrument in this form is designed to give full scale deflection on the eye-piece scale for 0.1 roentgen, and this is considered to be the maximum permissible daily exposure. For the purpose of measuring the intensity of strong x-ray beams an instrument is used in which the electrostatic capacity is increased by means of one or more concentric tubes inserted in the ionization chamber to form a condenser.

9. A high potential porcelain x-ray tube. RICHARD CRANE AND C. C. LAURITSEN, *California Institute of Technology.* An x-ray tube which operates successfully up to 650,000 volts has been constructed from a conical porcelain transformer bushing, rated at 750,000 volts external flashover. The porcelain is 5.5 ft. long and 18 inches inside diameter at the large end, and the whole tube is 9 ft. long. Although the bushing had previously been filled with transformer oil, no difficulties were encountered in outgassing the surfaces. With a pumping system of about 300 liters per second capacity, a vacuum of 10^{-5} mm can be maintained, and this does not change appreciably during operation. Cold emission from the anode, rather than gas current, limits the voltage which can be applied. Filament emission currents up to 4 milliamperes can be employed without undue heating of the target. For a given voltage, a porcelain tube of this type is much more compact than a glass tube, the strength of its walls against puncture makes elaborate internal shielding unnecessary, and there is no more difficulty in maintaining a good vacuum than in a glass tube of comparable volume. The source of high potential is the 1,000,000 volt transformer set in the High Tension Laboratory.

FRIDAY AFTERNOON, DECEMBER 16, 2:00 O'CLOCK

Lecture Hall, room 201

10. Secondary electron emission from tantalum. C. L. UTTERBACK AND E. ALLAN WILLIAMS, *University of Washington.*—The electron emission from tantalum was measured when the metal was bombarded with lithium ions. The source of the ions was $(Li_2O)(Al_2O_3)4SiO_2$ which, according to Hundley, (Phys. Rev. **30**, 864 (1922)), yields the isotope $(Li^7)^+$. The metal was cleaned with acid, well outgassed and the system washed out with oxygen. The system was then filled with oxygen at atmospheric pressure, allowed to stand for some time, and then evacuated. Without further outgassing the target, the electron emission and its percentage of the positive ion current was about one half of

its value when the target had been given a similar treatment with air. With an outgassed target the emission was much lower than when it contained either air or oxygen. The value of the positive ion currents was of the order of 6×10^{-10} amperes, and the electron current 2×10^{-10} amperes. In all cases, the percent emission was a linear function of the accelerating potential. The potentials from 400 to 1400 volts were used. As tantalum absorbs considerable oxygen, it is possible, that, on impact of the high velocity lithium ions, unstable compounds are formed which affect the emission. The effect of oxygen is similar to the effect of this gas on thermionic emission of tantalum, as found by Langmuir, (Phys. Rev. **2**, 450 (1913)).

11. The production of 4,800,000 volt hydrogen ions. M. STANLEY LIVINGSTON AND ERNEST O. LAWRENCE, *University of California.*—Improvements in the method recently described (E. O. Lawrence and M. S. Livingston, Phys. Rev. **40**, 19 (1932)) for the multiple acceleration of ions to high speeds have resulted in much higher energies. The method involves the resonance of ions with an oscillating electric field in a magnetic field. Enlargements in the physical size of the apparatus have led recently to the production of hydrogen ions of 3,600,000 volts energy (M. S. Livingston, Phys. Rev. **42**, 441 (1932)). Now by using two insulated electrodes instead of one the capacity in the oscillating circuit is reduced to half. This makes it possible to use shorter wave-lengths and larger magnetic fields for the resonance condition. With oscillations of 22.4 meters wave-length and a magnetic field of 17,550 gauss hydrogen molecular ions have been obtained with energies equivalent to 4,800,000 volt electrons. For nuclear disintegration studies, for which these ions are intended, this is equivalent to 2,400,000 volt protons. At 3,000,000 volts intensities of the order of 10^{-9} amps. are obtained and can certainly be increased. It appears probable that this intensity can also be obtained at the higher energies.

12. High velocity mercury ions. WESLEY M. COATES AND DAVID H. SLOAN, *University of California.*—The method of successive acceleration of mercury ions previously described by Sloan and Lawrence which gave particles of 1,250,000 electron-volts energy has been further devoloped so as to produce particles of 2,850,000 electron-volts energy. The resistance and the capacity of the accelerator system have been reduced so as to make possible increased efficiency and increased frequency of oscillation. The diameter of the accelerator tubes was considerably decreased without appreciably diminishing the intensity of the final beam, probably due to the focussing action previously noted. The number of accelerators was increased from 30 to 36 making their combined length 185 cm. The lowest wave-length used was 27.3 meters; the highest voltage applied was 70,000; the greatest step-up ratio used on the oscillator inductance was eight to one. Still higher velocity ions are believed to be attainable with the present tube. Preliminary measurements have shown that each ion upon striking a molybdenum plate produces from seven to ten secondary electrons, with energies of less than 30 volts. Some evidence that a fairly large fraction of the high velocity ions themselves are scattered from the molybdenum plate has been obtained. Further measurements will be necessary to test this possibility.

13. High voltage vacuum tube. DAVID H. SLOAN, *University of California.*—A 50 meter wave-length Tesla coil is mounted in an evacuated metal chamber and driven by a 70 kw vacuum tube oscillator. The water-cooled coil is supported only at its grounded end, and is entirely free from insulation; hence there is nothing to break down in the vacuum of 10^{-6} mm of Hg pressure. The free high voltage end of the coil is intended to support a hollow cylindrical electrode for accelerating ions into one end and out the other a half cycle later, effectively accelerating the ions to double the voltage of the coil. For the production of high voltage x-rays, an x-ray anode has been used on the free end of the coil (instead of the accelerating cylinder) together with a filament and biasing grid arrangement that gives emission only when the voltage on the anode is in the neighborhood of peak values, resulting therefore in the production of effectively high voltage d.c. x-rays. Absorption curves indicated 600,000 volt radiation with 5 milliamperes emission. The intensity of the radiation filtered by one half inch of steel at 50 cm from a copper target was about one roentgen unit per minute per milliampere.

14. The effect of temperature on the reflection of x-rays from bismuth crystals. A. GOETZ AND R. B. JACOBS, *California Institute of Technology.*—Previous experiments by Goetz and Hergenrother on the influence of temperature on the reflectivity of bismuth crystals for x-rays have been continued with higher accuracy. It has been found that the Debye-Waller relation for the temperature effect does not hold and that the deviation from it can not be ascribed in any simple manner to the occurrence of anharmonics of higher orders at high temperatures which should be expressed as well in the temperature coefficient of the thermal expansion. The existence of a thermal hysteresis for the integrated as well as the maximum reflection for Bi (111) Mo $K\alpha$ was found and thus the existence of a two-phase system within a crystal (amophorous and ideal crystal phase) as has been suggested previously seems to find support.

15. Magnetostriction in bismuth single crystals. A. WOLF AND A. GOETZ, *California Institute of Technology.*—The magnetostriction of bismuth single crystals has been measured in the longitudinal field of a solenoid at approximately 20,000 gauss in two different directions to the principal axis [111] of the crystal. The observations were made in stationary field conditions which renders the experiments isothermal in contradistinction to the adiabatic method of Kapitza. The crystals of pure Bi gave as moduli of magnetostriction (defined by $m_s=\Delta l/l=H^2/2\times m_s)m_{s\parallel}$ $=+5.7\times10^{-16}$ and $m_{s\perp}=-7.0\times10^{-16}$; i.e., the dilatation occurs parallel to [111] and a contraction normal to [111] within the direction of the field lines. These values support Kapitza's recent measurements quantitively fairly well. Furthermore, the influence of foreign atoms imbedded in the crystal was checked and the effects found have been

compared with the known influences on crystal diamagnetism: For impurities with one valency less than bismuth (Pb, Sn) a decrease of $m_{a\perp}$ was found which caused the effect to disappear ($m_{a\perp}=0$) at concentrations of 0.45% for Sn and 1.9% for Pb. For larger concentrations the effect changes its sign into a dilatation in which finally the values are almost twice as large as the original ones. The atomic influence on the magnetostriction reaches 0 in the neighborhood of concentrations close to the solubility limit of the admixture in bismuth. Similar but more complex effects were found for $m_{a||}$. Electronegative impurities (Te) have influences similar to the previous reported effects of electronegative admixtures on crystal-diamagnetism.

16. The thermal expansion of Bi single crystals. T. L. Ho and A. Goetz, *California Institute of Technology.*—The thermal expansion of Bi crystals with known admixtures of electronegative and electropositive impurities in small concentrations has been determined between room temperature and melting point. The decline of the expansion coefficient before the melting point as reported previously by Roberts and by the authors could be verified; it was found furthermore that admixtures cause definite changes in the thermal expansion at temperatures characteristic for the impurity present, which is interpreted by the influence such admixtures have on the habitus of the mosaic structure of these crystals.

17. Theory of the inverse first power electrostatic field. George C. Munro, *California Institute of Technology.*—The theory of the motion of an ion in an inverse first power electrostatic field resulting from a cylindrical section condenser has been studied under the particular set of conditions where all ions regardless of their energy enter the condenser normal to its leading edge and at the median position in the gap. Taylor series expressions have been obtained which give the exit position, the square of the exit velocity, and the tangent of the angle which the path of any ion beyond the electrostatic field makes with the corresponding line for the ion which travels in a true circle inside the gap. These expressions involve the charge and initial energy of the ion and the constants of the condenser. The existence and location of a virtual point source has been established for this system under the above conditions of collimation. It is intended that this system shall constitute the energy analyzer in the design of a modified Aston type mass spectrograph. The results of this work will be published in some detail as soon as some acceptable results are obtained from the spectrograph to be constructed in the near future.

18. The attainment of high vacua in large metal chambers. M. Stanley Livingston, *University of California.*—In the development of an apparatus for the production of high speed hydrogen ions (reported in a preceding abstract) a large metal chamber was used which could not be outgassed and was sealed with wax. The method necessitated a vacuum in which the mean free path was several hundred meters. A very high speed pumping system was obviously necessary. Although high speed mercury or oil diffusion pumps are now available, liquid air traps of corresponding speeds are difficult to construct. In the system reported here steel mercury diffusion pumps with a speed of approximately 25 liters/sec. were used, a Megavac furnishing the rough vacuum. Two liquid air traps in series, each fast but relatively inefficient were used, and a third exposed a liquid air cooled surface in the chamber itself. The overall speed of the pumping system was calculated to be 6 liters/sec. Pressures of below 5×10^{-7} mm of Hg were regularly obtained after 6 hours pumping and after 12 hours pumping a pressure of 1×10^{-7} mm of Hg was observed. These pressures were read on an ionization gauge of the standard type calibrated against a calibrated McLeod gauge.

SATURDAY MORNING, DECEMBER 17, 9:30 O'CLOCK

Lecture Hall, room 201

19. Some new coincidence measurements on the cosmic radiation. B. Sparks and W. Pickering. *California Institute of Technology.*—A new vacuum tube circuit has been developed for recording coincidences of two or more Geiger counters. The circuit includes the use of the Thyratron tubes, and has considerable advantages in regards to the elimination of accidental coincidences. Preliminary experiments with inert-gas filled Geiger counters will be briefly discussed. Results of experiments now in progress to determine whether absorption of the cosmic radiation by the sun or moon can be observed, will be reported upon. The authors hope to demonstrate the apparatus in continuous operation during the period of the meeting.

20. An electric-furnace ionization effect. Arthur S. King, *Mount Wilson Observatory.*—If a substance whose ionization potential is not too high is vaporized in the carbon-tube furnace, a temperature may be found which gives, providing abundant vapor is present, practically the whole neutral spectrum and the stronger lines of the ionized atom. A subsequent run of the furnace at the same temperature and total pressure, but with very little of the substance present, shows a spectrum in which the enhanced lines are relatively strong, or better interpreted, in which the neutral spectrum has faded. The neutral lines arising from high levels have disappeared, and those of low level are less persistent than the low-level enhanced lines. This effect, when examined under controlled conditions, was very distinct for the elements tested, these being calcium, strontium, barium, and neodymium. The phenomenon, which has several illustrations in astrophysics, may be explained as the result of conditions in which ionization is taking place freely, but recombination, on account of the few atoms present, is relatively infrequent. As a result of the reduced

supply of neutral atoms, the more difficult transitions producing the high-level lines rarely take place. The low-level lines, both neutral and ionized, remain, and at the limit the spectrum should consist of enhanced lines only, though the excitation is a moderate one.

21. The spectra of the calcium I-like ions: manganese VI, iron VII, cobalt VIII, and nickel IX. WILLOUGHBY M. CADY, *Harvard University and California Institute of Technology*.—The spectra of four new ions have been added to the sequence of spectra isoelectronic with Ca I. A vacuum spark produced the radiation, which was analyzed in a vacuum spectrograph with a concave grating set for grazing incidence. The transitions observed were those between the ground configuration, $3d^2$, and the lowest configuration that combines with it, $3d\,4p$. Nearly all the levels to be expected in these configurations were found, for all four spectra. almost all the allowed transitions among the observed levels were identified, as were several intercombinations and other forbidden lines. Slater's theory for the levels (neglecting fine-structure) in a configuration gives a good fit with the observed multiplets, especially in $3d\,4p$, which is remote from other odd configurations. in $3d^2$, $^1D_2$ is evidently perturbed by $3d\,4s\ ^{1,3}D$.

22. Zeeman effect in crystals. F. H. SPEDDING, *University of California*.—The transverse Zeeman effect on the absorption lines of $GdCl_3 \cdot 6H_2O$ has been photographed at various field strengths and at several temperatures of the crystal. Slides of the patterns obtained and of typical microphotometer curves will be shown. The results are explained on the assumption that if an electron is excited, as a first approximation, only its spin can orient in a magnetic field.

23. The auroral spectrum. JOSEPH KAPLAN, *University of California at Los Angeles*.—The first negative bands of nitrogen, which comprise most of the nitrogen radiation in the auroral spectrum, have been excited under conditions which suggest those in the aurora very closely. Active nitrogen is produced in uncondensed discharges in concentrations sufficient to give a strong visible glow. A very strong flash is observed at the beginning of the afterglow, and this flash indicates a high concentration of active material in the exciting discharge itself. Under the best conditions for the production of the afterglow the spectrum of the exciting discharge consists almost entirely of the first negative bands. The most important characteristic of these bands, as excited under the present conditions, is the absence of lines due to N^+. The usual excitation of the N_2^+ bands in discharges at low pressures produces these lines, whereas they are almost entirely absent in the auroral spectrum. The excitation of N_2^+ bands in the present experiments is thought to be due to the large concentration of metastable nitrogen molecules in the $A\,^3\Sigma$ state, and this experiment is presented as a proof of their presence in both the aurora and in nitrogen afterglows.

24. The extreme ultraviolet spectrum of molecular hydrogen. C. RULON JEPPESEN, *University of California*.—The spectrum of hydrogen in the extreme ultraviolet has been photographed by means of a new grazing incidence spectrograph containing a two meter grating. More than 2200 lines between 810A and 1375A have been measured. Of these over 1400 are new. The $2p\,^1\Sigma - 1s\,^1\Sigma (B-A)$ band system has been extended so that a number of bands ending on the three lowest vibrational levels are now included. The new data on the two lowest vibrational levels agree well with the published Ramon effect data. A new analysis of the $2p\,^1\Pi cd - 1s\,^1\Sigma (C-A)$ system has given more accurate values of the constants of the $2p\,^1\Pi cd$ state and has brought to light a number of perturbations. Rotational and vibrational constants for all observed levels in the three above named states have been derived, and tables of the value of the rotational energy function for each level have been constructed.

25. Mass ratio of the lithium isotopes from the spectrum of Li_2. ANDREW MCKELLAR, *University of California*. (*Introduced by* R. T. BIRGE.)—The blue-green band spectrum of lithium has been photographed, in absorption, in the second order of a 21-foot grating. The (0, 0), (1, 0) and (2, 0) bands were measured and in the first two of these the branches due to the less abundant Li^6Li^7 molecule, as well as those of the Li^7Li^7 molecule were identified, extending the analyses of Harvey and Jenkins, and of Wurm. By applying the least squares methods developed by Birge in his work on the oxygen isotopes, the vibrational term differences of the upper, $^1\Pi$, state were found. From these, employing the theory of the vibrational isotope effect in band spectra, the square root of the ratio of the reduced masses of the isotopic molecules, $\rho = (\mu/\mu')^{1/2} = \omega_e'/\omega_e$ is found to equal 1.04103 ± 0.00018. The mass-spectrograph results of Costa, modified by Aston, give for the atomic weights of the lithium isotopes, 7.012 ± 0.002 and 6.012 ± 0.002 from which the mass ratio $Li^7/Li^6 = 1.16633$ with a *limit* of error ± 0.00051. The above value of ρ corresponds to the ratio $Li^7/Li^6 = 1.16750$ with a *probable* error ± 0.00073, giving a fairly satisfactory agreement of the two results. The latter ratio gives, assuming that $Li^6 = 6.012$, a packing fraction of 27 for Li^7, which falls directly on Aston's curve of packing fraction against mass number.

26. A new analysis of Slater's compressibility data. H. M. EVJEN, *California Institute of Technology*.—On the basis of empirical relations derived from Slater's compressibility data for the alkali halides a set of differential equations is constructed. The general solution of this set of equations is derived, whereby the most general form is obtained for the potential of repulsion. Whereas a curious and very striking agreement with Born's theory is pointed out, this theory is again repudiated by a more general argument than has heretofore appeared in the literature. By the assumption that the repulsive forces are essentially a result of an interaction along the "atomic boundaries" a unique solution is obtained by functional analysis. This solution has many interesting features and is in many respects similar to the representations of the repulsive force which have been suggested on the basis of quantum theoretical considerations.

27. On cooperative phenomena. F. ZWICKY, *California Institute of Technology.*—The study of a so far neglected type of effects, which may be called *cooperative phenomena* is proposed. It is shown that these phenomena play a great role in astrophysics, in the physics of solids and liquids and will probably be essential for a study of the physical characteristics of living organisms. A preliminary classification of various types of cooperative phenomena is given. As a particular case the physics of crystals is studied and the view advanced that certain cooperative phenomena are responsible for the existence of a crystalline state of matter. If this view is accepted then it follows that crystals in general possess a *secondary structure*. The experimental consequences of this conclusion are discussed.

28. The latitude effect on secondary electrons due to cosmic rays. R. M. LANGER, *California Institute of Technology.*— Two simplified problems were examined to determine whether cosmic-ray intensity measurements would be influenced by the action of the terrestrial magnetic field on secondary electrons released in the atmosphere. 1st. Electrons move with constant curvature through an atmosphere whose density varies exponentially with height. 2nd. Electrons move through a uniform atmosphere with curvature increasing as their energy decreases. The important parameters—rate of loss of energy along the path and curvature at any height in the atmosphere—are not definitely known but the conclusions are not affected by the uncertainty. It is believed that the simplifications are appropriate and do not invalidate the argument for application to the actual case. Moreover it seems that the two problems practically exhaust the possibilities for electrons generated in the atmosphere. The conclusion is that for any reasonable values of the parameters involved, no latitude effect as large as three percent is to be expected for electrons generated in the earth's atmosphere. The conclusion holds for measurements made at altitudes up to 20,000 feet at least.

29. Sound absorption in molecular gases. H. O. KNESER, *University of Marburg. Introduced by Professor L. B. Loeb.*— The present data on absorption of sound in molecular gases do not agree with the classical Kirchhoff-Stokes formula, either in the order of magnitude or in the dependence upon frequency (ν). Now that it has been established, that sound dispersion, caused by the finite duration (β) of adjustment of internal energy equilibrium, occurs at frequencies which can be realized experimentally, sound absorption can be explained in the same way. If β is of the same order of magnitude as $1/2\pi\nu$, there is a phase lag between the variation of volume and pressure, which causes an irreversible transformation of sound energy into heat. Thus, in addition to the classical absorption, we have selective absorption in nearly the same range of frequency as that in which dispersion occurs. The absorption can be calculated exactly for those gases whose dispersion curve is known (CO_2 and N_2O), and is in good agreement with the experimental data. In other cases (O_2, SO_2) β can be evaluated by fitting the absorption curve to the experimental values. Thus almost all present data can be explained within the limits of experimental error.